

Bias and Precision of Age Estimates

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```
Age <- read.csv("Data/Raw-Data/2016_largemouth-bass_age-estimates_raw.csv") %>%
  dplyr::select(FID:Difference) %>%
  arrange(FID)
Age$FID <- factor(Age$FID)
length(Age$FID)

## [1] 132
Age[Age$FID==55,];FID55 <- as.numeric(rownames(Age[Age$FID==55,]))

##      FID AgerA AgerB AgerC Difference
## 55    55      2      2      2         NO
Age <- Age[-c(FID55),] %>%
  filterD(!is.na(FID)) ### Remove outliers
length(Age$FID)

## [1] 131
str(Age)

## 'data.frame':   131 obs. of  5 variables:
##  $ FID      : Factor w/ 131 levels "1","2","3","4",...: 1 2 3 4 5 6 7 8 9 10 ...
##  $ AgerA     : int   4 4 4 6 4 NA 1 2 4 8 ...
##  $ AgerB     : int   4 4 4 6 4 NA 1 2 4 8 ...
##  $ AgerC     : int   4 4 4 6 4 NA 4 2 4 8 ...
##  $ Difference: Factor w/ 2 levels "NO","YES": 1 1 1 1 1 NA 2 1 1 1 ...
#write.csv(Age,file="Data/Clean-Data/2016_largemouth-bass_age-estimates_clean.csv")
```

Comparing Age Estimates Between 3 Readers

```
ab.AB <- ageBias(AgerA~AgerB, data=Age, ref.lab = "Ager B", nref.lab = "Ager A")
#1-8-2018#save(ab.AB, file = "model-output/ab.AB.rda")

ab.AC <- ageBias(AgerA~AgerC,data = Age,ref.lab = "Ager C", nref.lab = "Ager A")
#1-8-2018#save(ab.AC, file = "model-output/ab.AC.rda")

ab.BC <- ageBias(AgerB~AgerC,data = Age,ref.lab = "Ager C", nref.lab = "Ager B")
#1-8-2018#save(ab.BC, file = "model-output/ab.BC.rda")
```

Bias

Three readers made independent reads of Largemouth Bass otoliths to determine the age of Largemouth Bass in our sample. Now we will look for bias between the 3 readers (readers A, B, C). We will use age bias plots to do this.

Bias Alex (AgerA) vs Jim (AgerB) Age Est.

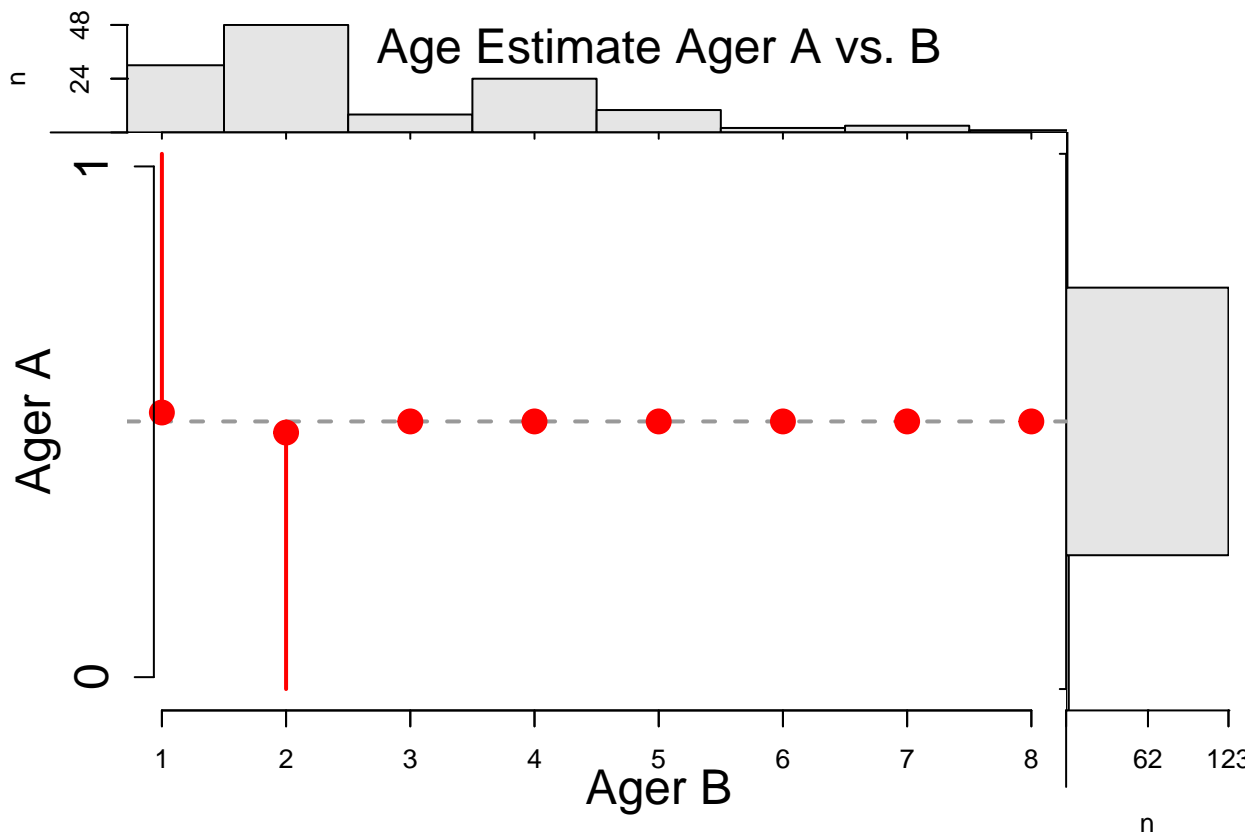
```
plot(ab.AB, col.CIsig = "Black", show.range = TRUE, main = "", bty = "n", lwd = 2,
     lwd.CI = 2, lwd.range = 2, lwd.agree = 2, col.CI = "red", col.range = "red",
     cex.n = 1.25, cex.axis = 1.5, yaxt = "n", xlab = "", ylab = "")

## Warning in plot.window(...): "cex.n" is not a graphical parameter
## Warning in plot.xy(xy, type, ...): "cex.n" is not a graphical parameter
## Warning in axis(side = side, at = at, labels = labels, ...): "cex.n" is not
## a graphical parameter

## Warning in axis(side = side, at = at, labels = labels, ...): "cex.n" is not
## a graphical parameter

## Warning in box(...): "cex.n" is not a graphical parameter
## Warning in title(...): "cex.n" is not a graphical parameter

axis(2, at = seq(0, 8, 1), cex.axis = 1.5)
mtext("Ager A", side = 2, cex = 1.5, line = 2.5)
mtext("Ager B", side = 1, cex = 1.5, line = 2.5)
mtext("Age Estimate Ager A vs. B", side = 3, cex = 1.5, line = 2.5)
```



```
### Statistics behind age bias plot
```

```
SumAB.bias <- summary(ab.AB, what = "bias")
```

##	AgerB	n	min	max	mean	SE	t	adj.p	sig	LCI	UCI
##	1	30	1	2	1.03	0.0333	1.00	0.326	FALSE	0.965	1.10
##	2	48	1	2	1.96	0.0291	-1.43	0.319	FALSE	1.900	2.02
##	3	8	3	3	3.00	NA	NA	NA	FALSE	NA	NA
##	4	24	4	4	4.00	NA	NA	NA	FALSE	NA	NA
##	5	10	5	5	5.00	NA	NA	NA	FALSE	NA	NA
##	6	2	6	6	6.00	NA	NA	NA	FALSE	NA	NA
##	7	3	7	7	7.00	NA	NA	NA	FALSE	NA	NA
##	8	1	8	8	8.00	NA	NA	NA	FALSE	NA	NA

```
summary(ab.AB, what = "symmetry") ### Alex's age est (A) not biased compared to Jim (B)
```

##		symTest	df	chi.sq	p
##	1	McNemar	1	0.3333333	0.5637029
##	2	EvansHoenig	1	0.3333333	0.5637029
##	3	Bowker	1	0.3333333	0.5637029

```
summary(ab.AB, what = "table")
```

##		Ager B							
##	Ager A	1	2	3	4	5	6	7	8
##	1	29	2	-	-	-	-	-	-
##	2	1	46	-	-	-	-	-	-
##	3	-	-	8	-	-	-	-	-
##	4	-	-	-	24	-	-	-	-
##	5	-	-	-	-	10	-	-	-

```
##      6 - - - - - 2 - -
##      7 - - - - - - 3 -
##      8 - - - - - - - 1
```

Bias Alex (AgerA) vs Steve (AgerC) Age Est.

```
plot(ab.AC, col.CIsig = "Black", show.range = TRUE, main = "", bty = "n", lwd = 2,
     lwd.CI = 2, lwd.range = 2, lwd.agree = 2, col.CI = "red", col.range = "red",
     cex.n = 1.25, cex.axis = 1.5, yaxt = "n", xlab = "", ylab = "")
```

```
## Warning in plot.window(...): "cex.n" is not a graphical parameter
```

```
## Warning in plot.xy(xy, type, ...): "cex.n" is not a graphical parameter
```

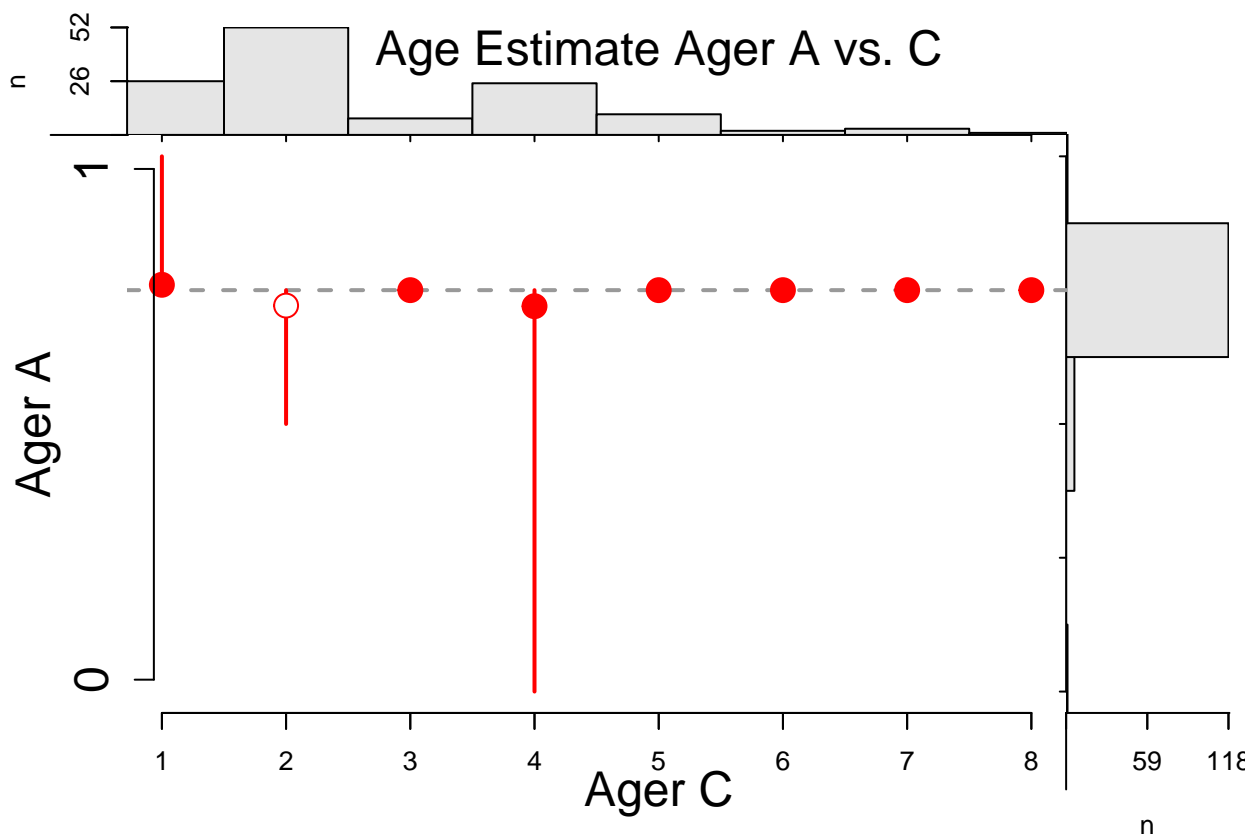
```
## Warning in axis(side = side, at = at, labels = labels, ...): "cex.n" is not
## a graphical parameter
```

```
## Warning in axis(side = side, at = at, labels = labels, ...): "cex.n" is not
## a graphical parameter
```

```
## Warning in box(...): "cex.n" is not a graphical parameter
```

```
## Warning in title(...): "cex.n" is not a graphical parameter
```

```
axis(2, at = seq(0, 8, 1), cex.axis = 1.5)
mtext("Ager A", side = 2, cex = 1.5, line = 2.5)
mtext("Ager C", side = 1, cex = 1.5, line = 2.5)
mtext("Age Estimate Ager A vs. C", side = 3, cex = 1.5, line = 2.5)
```



```
### Statistics behind age bias plot
SumAC.bias <- summary(ab.AC, what = "bias")
```

```
## AgerC  n min max mean      SE      t adj.p  sig  LCI  UCI
##      1 26   1   2 1.04 0.0392  1.02 0.6352 FALSE 0.959 1.12
##      2 52   1   2 1.88 0.0447 -2.58 0.0385  TRUE 1.795 1.97
##      3  8   3   3 3.00      NA      NA      NA FALSE      NA  NA
##      4 25   1   4 3.88 0.1200 -1.00 0.6352 FALSE 3.632 4.13
##      5 10   5   5 5.00      NA      NA      NA FALSE      NA  NA
##      6  2   6   6 6.00      NA      NA      NA FALSE      NA  NA
##      7  3   7   7 7.00      NA      NA      NA FALSE      NA  NA
##      8  1   8   8 8.00      NA      NA      NA FALSE      NA  NA
```

```
summary(ab.AC, what = "symmetry") # McNemar Suggests some age Bias between Alex and Steve
```

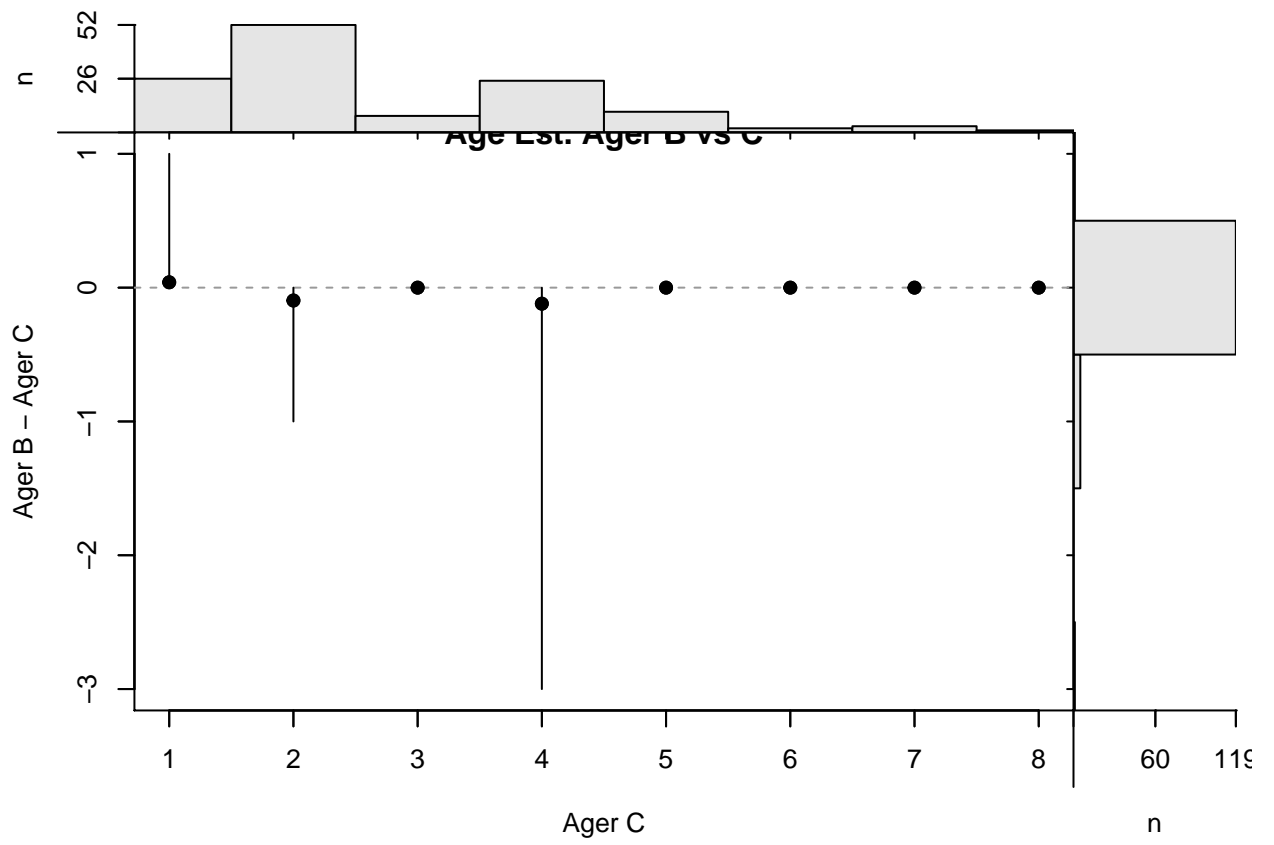
```
##      symTest df    chi.sq      p
## 1      McNemar  1 4.500000 0.03389485
## 2 EvansHoenig  2 4.571429 0.10170139
## 3      Bowker  2 4.571429 0.10170139
```

```
summary(ab.AC, what = "table")
```

```
##      Ager C
## Ager A  1  2  3  4  5  6  7  8
##      1 24  6 -  1 - - - -
##      2  1 46 - - - - - -
##      3 - -  8 - - - - -
##      4 - - - 24 - - - -
##      5 - - - - 10 - - -
##      6 - - - - -  2 - -
##      7 - - - - - -  3 -
##      8 - - - - - - -  1
```

Bias Steve (AgerC) vs Jim (AgerB) Age Est.

```
plot(ab.BC, col.CIsig = "Black", show.range = TRUE, main = "Age Est. Ager B vs C")
```



```
### Statistics behind age bias plot
summary(ab.BC, what = "bias")
```

```
##   AgerC  n min max mean      SE      t adj.p   sig   LCI   UCI
##     1 26   1   2 1.04 0.0392  1.02 0.6352 FALSE 0.959 1.12
##     2 52   1   2 1.90 0.0413 -2.33 0.0715 FALSE 1.821 1.99
##     3  8   3   3 3.00      NA      NA      NA FALSE      NA   NA
##     4 25   1   4 3.88 0.1200 -1.00 0.6352 FALSE 3.632 4.13
##     5 10   5   5 5.00      NA      NA      NA FALSE      NA   NA
##     6  2   6   6 6.00      NA      NA      NA FALSE      NA   NA
##     7  3   7   7 7.00      NA      NA      NA FALSE      NA   NA
##     8  1   8   8 8.00      NA      NA      NA FALSE      NA   NA
```

```
summary(ab.BC, what = "symmetry") # close but no age bias between jim and steve
```

```
##           symTest df    chi.sq      p
## 1      McNemar   1 3.571429 0.05878172
## 2 EvansHoenig   2 3.666667 0.15987975
## 3      Bowker    2 3.666667 0.15987975
```

```
summary(ab.BC, what = "table")
```

```
##           Ager C
## Ager B  1  2  3  4  5  6  7  8
##     1 24  5  -  1  -  -  -  -
##     2  1 47  -  -  -  -  -  -
##     3  -  -  8  -  -  -  -  -
##     4  -  -  - 24  -  -  -  -
##     5  -  -  -  - 10  -  -  -
##     6  -  -  -  -  -  2  -  -
##     7  -  -  -  -  -  -  3  -
##     8  -  -  -  -  -  -  -  1
```

Precision

We will assess precision of age estimates using average coefficient of variance but will also look at some other metrics.

```
ap.ABC <- agePrecision(~AgerA + AgerB + AgerC, data = Age)
```

```
summary(ap.ABC, what = "difference")
```

```
##           -3      -2      -1       0       1
## AgerA - AgerB 0.0000 0.0000 1.5873 97.6190 0.7937
## AgerA - AgerC 0.7937 0.0000 4.7619 93.6508 0.7937
## AgerB - AgerC 0.7937 0.0000 3.9683 94.4444 0.7937
```

```
SumABC.Prec <- summary(ap.ABC, what = "precision")
```

```
##      n validn R    ACV    APE PercAgree
## 131    126 3 3.162 2.434    92.86
```

FID	AgerA (Alex)	AgerB (Jim)	AgerC (Steve)
7	1	1	4
27	1	1	2
29	1	1	2
34	1	1	2
35	1	2	2
63	1	2	2
71	2	2	1
90	2	1	2
122	1	1	2

There is some disagreement about the age of some fish (FIDs 7,27,29,34,35,63,71,90,122) and some have not been aged at all (FIDs 6,28,79,81,124). I may remove these fish when fitting the growth model.

Age estimates were similar between all three readers (AgerA, AgerB, and AgerC). AgerA was found to underestimate the ages of 2 year old fish when compared to AgerC ($t = -2.58$, $p = 0.038$) but not when compared to AgerB ($t = -1.43$, $p = 0.319$). We found no other significant bias in the age estimations made by the three readers. **Fish with inconsistent age estimates ($n = 9$) were removed from later analysis to eliminate this bias [(or) will be assigned ages based on the majority agreement between 2 readers]**. Overall, there was a high level of precision between age estimates provided by our three readers ($n = 126$, 92.86 % Agreement, ACV = 3.16).